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REV. J. L. ZABRISKIE,

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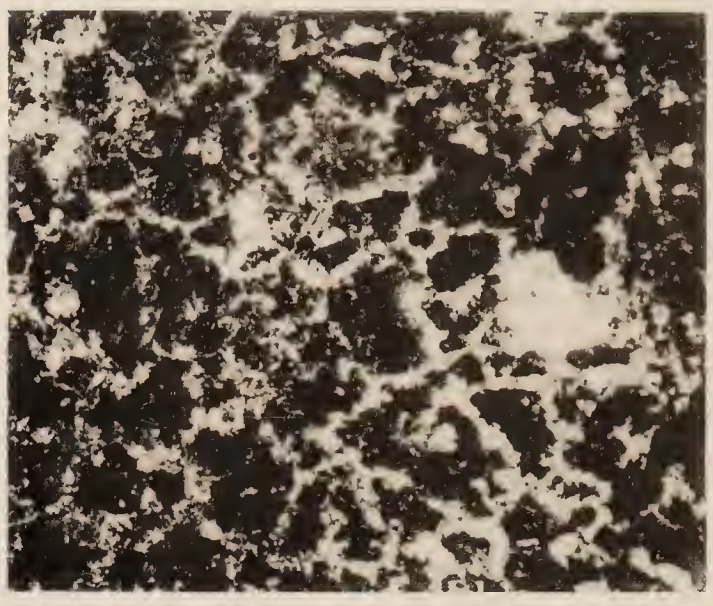

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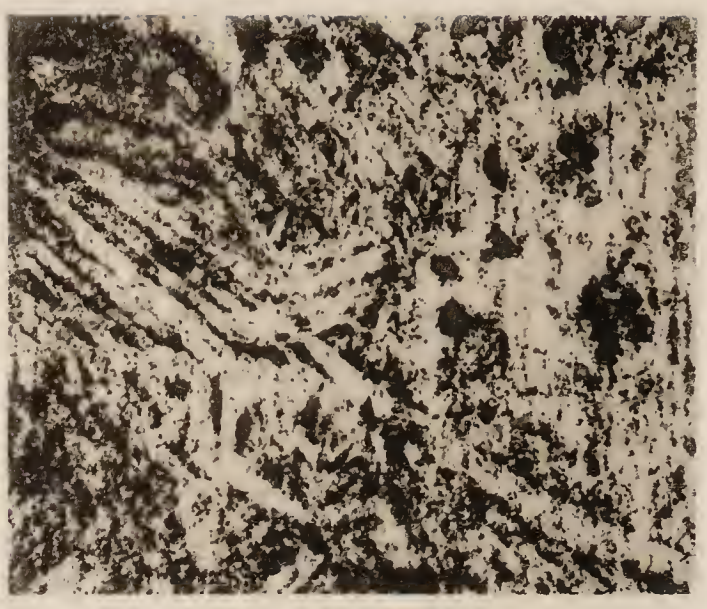

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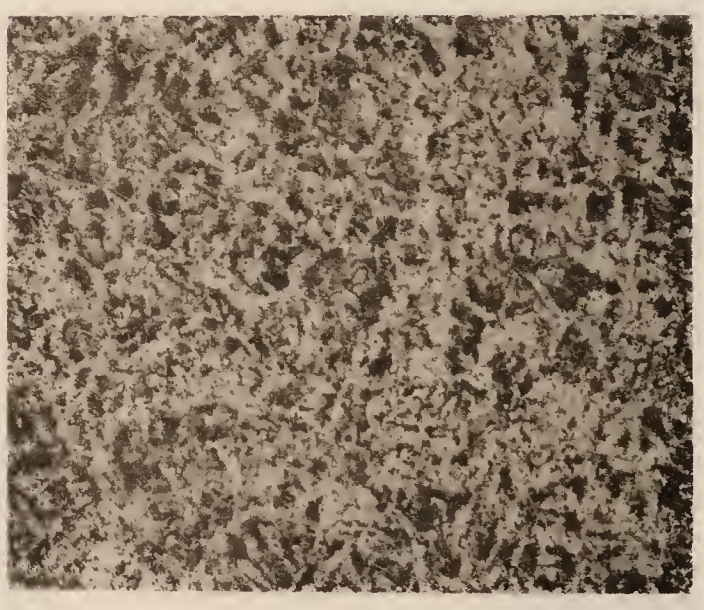

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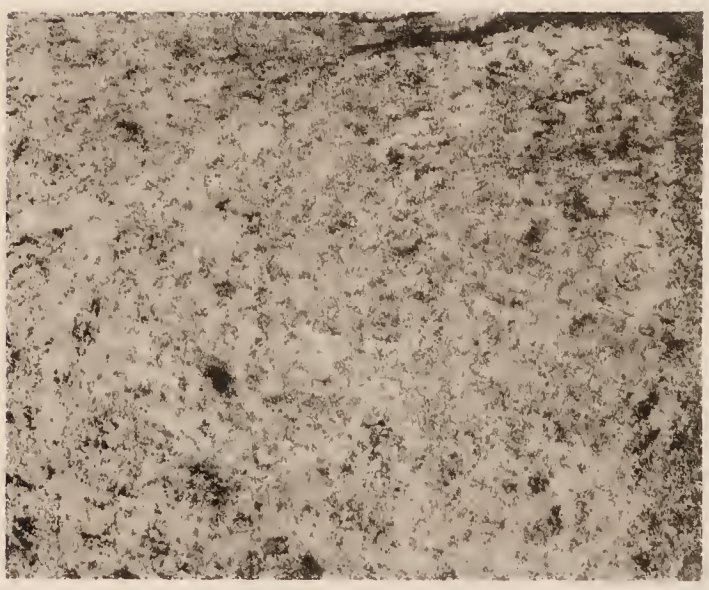

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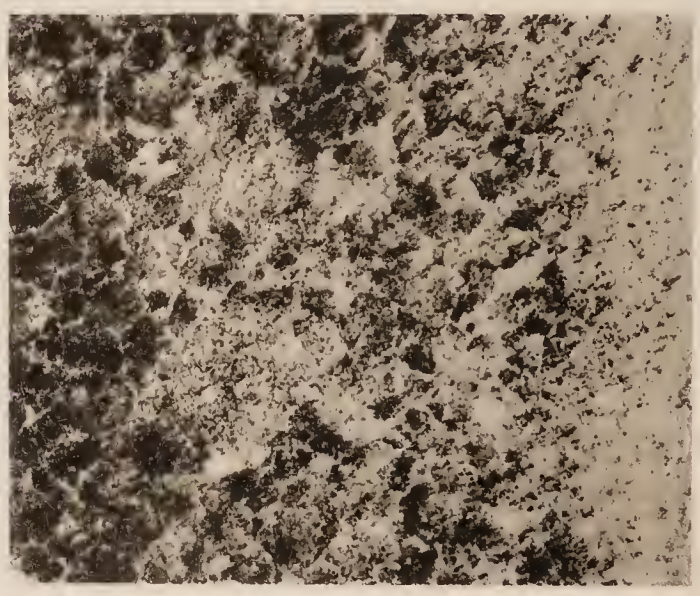

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DUDLEY ON STRUCTURE IN STEEL.

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VOL. VIII. JULY, 1892. No. 3.

STRUCTURE IN STEEL.

ANNUAL ADDRESS OF THE PRESIDENT, P. H. DUDLEY.

(Read January 5th, 1892.)

Steel being an inorganic compound, the fact is overlooked that when molten the enormous forces of crystallization are only held in check by the intense heat, and, as the steel cools, more or less structure is produced.

Conditions which would affect the fineness or coarseness of texture in rail steel were given in my previous paper upon the same

Explanation of Plate 32.

FIG. 1 is from the exterior surface of a 50 carbon Bessemer rail ingot. The white lines enclosing the mineral aggregates, in this case, indicate more strongly the polyhedral than the columnar structure of the ingot. — FIG. 2 is from a .03 nickel armor plate ingot. The polygonal structure is large, from one-twentieth to one-tenth of an inch in diameter. The junction of three polygons is shown near the centre of the figure. The carbide of iron (?) is distributed in thin laminæ, a small amount of the charcoal, work, and heat treatment rendering the steel homogeneous and exceedingly tough.— FIG. 3 is from fluid, compressed, open-hearth steel, after the first hydraulic forging. The carbide of iron is well distributed, though it has not reached the homogeneous condition it will have after further forging and heat treatment.—FIGS. 4, 5, and 6 are from a .26 carbon Bessemer steel rail, from the Boston & Albany Railroad, after ten years' service. Fig. 6 shows the structure in the head of the rail, the polygons being nearly as coarse as in the structure of Fig. 1. The white lines show the distribution of the carbide of iron, while the interior portions of the aggregates are much softer (?), and break down near the upper surface of the rails, from the load of the passing wheels, as shown in Fig. 4, and then flow off to the side of the rail, as shown in Fig. 5, large pieces eventually becoming detached. The structure of the surface of the rail is broken down for one-twentieth of an inch in depth, the rail having lost three fourths of an inch in height in ten years' service. The metal in flowing soon reaches its percentage of elongation, and cracks, or shears from the metal underneath. (See Figs. 4, 5.)—FIG. 7 is from a rail made in 1865, and was in service over twenty years, under heavy traffic. The structure is very fine, and the loads upon the wheels have affected the metal but little over one-hundredth of an inch in depth from the surface.—FIG. 8 is from a .60 carbon rail head, the structure hardly traceable, fine, and dense.

subject. Similar conditions generally apply to other grades of steel, so far as the texture is concerned.

The fact of the great forces of crystallization present in molten steel prevents finding steel after casting to be a homogeneous, structureless compound, but it is composed of several, with more or less structural detail. In other words, our steel ingots are built up of great numbers of mineral aggregates, and to bring the steel into the highest physical condition we must reduce or render the mass as homogeneous as possible and give toughness to the metal as well.

The wonderful and important property of carbon uniting with iron at temperatures below fusion has long been known, especially in regard to tool steels; another property being that this union lowers the melting point of iron and renders it possible to cast it as iron, or, when the carbon is present in lesser quantities, to cast the product as steel.

The first-mentioned property of carbon forms new structure and compounds at different temperatures, or diffuses the carbon in a different manner, and can hold the structure of different temperatures when suddenly cooled.

Another useful property of the compound of carbon and iron is that of hardening upon being heated to a cherry red and suddenly quenching in water, oil, molten lead, and several other similar media. Certain degrees of hardness can be given to steel, according to the use the steel is to subserve.

The same fact seems to be true of the open-hearth and Bessemer steels, and advantage is now taken of it to improve the quality of large masses of steel by heat treatment, as well as depending upon chemical composition and mechanical work. This heat treatment consists in raising the temperature of the steel to the degree which gives the desired structure, and then fixing this structure, which will be hard but more or less brittle, by cooling quickly in some media. To give toughness to the steel it is then annealed at a temperature below quenching. This permits some rearrangement of the compounds. A part of the hardening carbon is converted into cement carbon, which lessens the hardness and brittleness of the remaining hardening carbon.

The results already reached of improving the physical properties of steel of the same chemical composition by heat treatment are

so important that all nations have modified the construction of their ordnance from solid guns to the system of built-up guns, each part not being too large to receive the full benefit of heat treatment.

To illustrate the changes in the structure of steel by mechanical work and heat treatment, I have specimens of open-hearth compressed steel for ordnance—

1. From the ingot.
2. After hydraulic forging.
3. After heat treatment.

These are designated as specimens Nos. 1, 2, and 3.

The steel contains about .40 carbon, and after being poured into the cylindrical ingot mould, 30 inches in diameter and 18 feet long, was put under compression of 2,000 pounds per square inch to prevent the formation of blow holes or a pipe in the ingot. The steel was several hours in setting; many more in cooling, and, notwithstanding the compression, the facets of the imperfect crystals are from one-twentieth to one-tenth of an inch square and distinctly foliated, fracture occurring through this structure instead of through the crystals. In turning such steel under heavy feed the imperfect crystals often tear out instead of cutting through. The tensile strength of such steel rarely reaches 40,000 pounds and has but little elongation in a test specimen. The structure, as shown in specimen No. 1, is very coarse.

Specimen No. 2 is a tensile test bar taken from the steel after heating and forging. Though the coarse structure has been somewhat reduced, the exterior of the bar has a reticulated surface, showing the elongation of the bar is more decided through the foliated structure than through the crystals, and that the steel is not in its best condition.

Specimen No. 3 is a tensile test bar after heat treatment. The tensile strength is over 100,000 pounds per square inch, and the test bar is very smooth on the surface. The crystalline structure has been very completely reduced. The steel has not only high elastic limits, but when they are reached the metal will give many per cent of elongation before fracture occurs. The end of the broken test bar has a decided silky fracture, showing the metal to be very uniform in structure and in excellent condition for severe service, as in ordnance. For projectiles the steel could be much harder.

Specimen No. 4 under the microscope is an etched piece of metal from specimen No. 1 as it came from the ingot. Bright lines forming polygonal structures enclosing the imperfect crystals are quite distinct, while more delicate lines, extending from the polygonal structures into the crystals, can also be seen at a few points. The mottled appearance of most of the interior of the crystals, caused by bright metallic points, may not, in the plane of one etching, be traced to the polygonal lines.

Specimen No. 5 is an etched piece from specimen No. 2. The polygonal lines cannot be traced, because the coarse structure is reduced. The bright lines are abundant and interspersed through the steel in every direction as rather thick laminæ. Specimen No. 2, the test bar after testing, shows the steel to have a rough and reticulated surface on account of not being homogeneous. This is the poor structure of soft rails and those which do not wear well.

Specimen No. 6 is an etched piece from test bar No. 3. The bright lines are no longer distinct, but are well dispersed through the steel, and the structure is homogeneous, which explains the smooth appearance of the broken test bar.

In specimen No. 7—an etched piece of metal from a Bessemer .50 carbon rail ingot by another method of treatment—the lines forming the polygonal structure have been more deeply etched than the other portions of the steel.

The polyhedral structure of the Bessemer rail ingot is very clearly indicated, as specimens Nos. 8 and 9 will confirm. The ingot was not compressed, as that would add largely to the cost of the rails and limit the output. The same objections would apply to subsequent heat treatment of the rails, and we are obliged to resort to other methods of reducing the coarse structure in the ingot to a finer and more enduring one for the rails.

The acid Bessemer process for producing steel is a very rapid one, by blowing air of 25 to 28 pounds pressure per square inch through a bath of molten cast iron in a converter to decarbonize it, though really burning out first the silicon, then the carbon, leaving in the bath the iron partially oxidized, all of the phosphorus, sulphur, copper, and traces of other minerals contained in the ores and fuel. To convert this molten metal into steel of the required grade a definite weight of molten spiegel mixture is added.

This contains the desired carbon, manganese, and silicon to produce the grade of steel desired.

The product is then poured from the converter into the casting ladle, and from the latter into cast-iron ingot moulds of $14\frac{1}{2}$ or 16 inches square, or 16 by 19 inches on the base, as the case may be. These moulds stand vertically in pits and are filled with 4 or 5 feet of molten metal. Chilling and congelation begin as soon as the metal is poured; crystallization forming structure in the ingot, the character of which is dependent upon the grade of the steel, its impurities, size of the ingot, rate of solidification, and particularly the rate of cooling.

In Bessemer rail-steel ingots of $14\frac{1}{2}$ inches or 16 inches square on the base, of the grades of .50 and .60 carbon, the chilling of the exterior surfaces in contact with the mould induces a decided columnar structure, extending at right angles from the mould 1 to 3 inches into the interior of the ingot, then there is more decidedly polyhedral structure to the centre of the ingot. In the upper portion of the ingot a pipe is apt to develop, also gas cavities. In the pipe and cavities traces of crystals are present, the former especially often being studded with perfect forms of pine-tree crystals.

In the blow holes, in the columnar structures of the grades of steel mentioned, I have always found traces of crystallization. There seem to be two systems, in which the main axes are in parallel rows, the lateral axes appearing at right angles to the main axes, forming a series of projecting points at right angles to one another in two directions; in the other system the base of the points seemingly being surrounded by hexagons.

Specimen No. 10 shows the decided columnar structure of the exterior of a .60 carbon ingot. In another specimen of a lower grade of steel blow holes have formed in the columnar structure.

Returning to specimens Nos. 8 and 9, which formed a transverse section from the exterior to the centre of the ingot, the exterior blow holes may be noticed, though the columnar structure has been modified by long-continued heat, while the polyhedral structure has been more strongly developed than usual. The mould could not be stripped from this ingot, and was broken under a drop, and in doing so the ingot was broken. The ingot was many hours in cooling, and quite well-developed octahedral crys-

tals formed, producing a structure which was not strong under shock, fracture taking place between instead of through the crystals. So well-defined structure I have only found in a rail head once, and that was the rejected rail from which specimen No. 2, described in my previous paper, was taken. It is a form of structure I do not wish to find either in the ingot or in the rail. Several attempts were made to break up the structure as formed in the rail head, and while a considerable modification was made, removing some of the brittleness of the metal, the structure was not completely effaced. It seems much safer to prevent its formation than to try and break it up afterwards.

In specimen No. 9, of the same ingot, in one of the gas cavities you will see the well-developed pine-tree crystals. The same form of crystals also studded the pipe which formed in the upper part of the ingot.

In the practice of making rails, the ingots as soon as stripped, 8 to 12 minutes after casting, are charged into a reheating furnace or soaking pit to equalize the temperature before blooming. In the latter operation many of the gas cavities and portions of the pipe become closed. The portion of the bloom in which the pipe is not closed is cut out. It is often the case that the interior of the ingot is not fully solidified upon reaching the blooming train, more or less segregation having taken place, producing an entirely different structure in the centre of the rail. This is not desirable, as the rails are liable to be brittle. Specimens Nos. 11, 12, and 13 are pieces from such rails which failed to stand a drop test of 2,000 pounds falling 20 feet, the rail butt resting upon steel supports of 4 feet span. Before placing the rail upon the supports the base is stamped into inch sections, so the percentage of elongation can be ascertained; any rail failing to give five per cent elongation, the entire rails of the heat are rejected. The carbon and manganese are usually much greater in the central portions of such ingots. In specimen No. 11 the average carbon of the heat was .48 and the manganese .90. In the centre of the ingot the carbon was .60 and the manganese 1.48 per cent. In specimen No. 12 segregation occurred in the metal forming the centre of the head of the rail, the surrounding metal also being weak and easily fractured.

Specimen No. 14 shows a piece of tough rail which was placed

upon the side, the drop of 2,000 pounds falling 20 feet upon the upper edge of base and side of the head, causing the lower edge of the base to elongate 18 per cent per inch for at least 6 inches in length. The rail rebounding from the blocks after the drop struck, it dropped to the foundation of the ingots supporting the blocks, the base wedging between two ingots. The fall of the rebounded drop broke out this piece containing the inch spacings. The fracture in this case is much coarser than would have been the case had the rail failed under the full drop.

Specimens Nos. 15, 16, 17, 18, and 19 are longitudinal sections of pit-test ingots, showing the piping and the gas cavities which are liable to form. In rolling these for bending tests they are not allowed to cool and some of these cavities are closed.

Nos. 15, 16, and 17 are from the same heat of steel, Nos. 15 and 16 being the parts of the same ingot.

Specimen No. 17 is an ingot on which I made the experiment of seeing how much additional carbon would be absorbed by having one side of the mould a plate of carbon. The steel, as poured into the ingot, contained .48 of carbon, was chilled in less than ten minutes, remained in the mould and was cooled in two hours. The first sixteenth inch averaged 1.48 of carbon, the second sixteenth inch .81, and the third was nearly normal. This shows a very rapid and unexpected rate of absorption of carbon, and we can readily understand the diffusion of carbon from the walls surrounding crystals to the crystals, or vice versa, at temperature below fusion. This can also be understood by the process of cementation imparting carbon to iron plates, to make crucible steel. The process of making molten steel take up an additional amount of carbon by absorption permits of graduations of carbon in the same ingot.

Specimens Nos. 18 and 19 are from the same heat of steel, though in No. 18 a small amount (one hundredth of one per cent) of aluminium was added to see its effect upon lessening the blow holes and gas cavities in the steel. The former were reduced, the latter prevented, though the pipe of the ingot was increased. The tensile strength and elongation of the metal were slightly augmented.

With the rapid output of the rail mills, and only 11 passes in the rail trains, it seems important, in order to secure a good

wearing rail of dense metal in the head, to start with a good chemical composition as a basis; the carbon .50 or more; to make a small texture in the ingot; avoid long or over-heating; have a section of rail with a thin head to be well worked, a thick base and heavy web to equalize the heat in the section to give toughness to the metal and not brittleness.

The foliated structure we see between the crystals, and a similar structure which has built them up, become reduced to more delicate laminæ as the imperfect crystals are broken up by mechanical work. The soft steels do not have sufficient cohesion to prevent flow under the loads of the present day. To give such steel strength mechanical work must be done upon the plates, or some elements added which will modify the structure or increase the cohesion of the laminæ.

The first steel rails of only .25 to .4 of carbon, with thin heads, thick bases and webs, made with 23 passes in the rail train, had fine structure in the heads and were excellent rails, though in a few years the sections were not stiff enough for the increasing traffic. Noticing that the rate of wear was very slow in the head, the conclusion was soon reached that massive heads, thin bases and webs would give the longest service. This soon became the style of all new sections. The structure, from a fine one in the heads of old rails, became coarse in the new and wore out at much faster rate. Then a hasty conclusion was reached, from an insufficient investigation, that a small amount of carbon in the rails, low manganese, silicon and phosphorus not exceeding .10, would make better wearing rails than higher grades of steel. We have had an era of massive heads, coarse structure, and soft rails which have not given long service. The metal not only rapidly abrades, but flows, and is forced from the rails. This is illustrated by specimens Nos. 20, 21, and 22. Slower-wearing rails are shown in specimens Nos. 23 and 24, the latter having had double the number of years' service of Nos. 20, 21, and 22.

Specimens Nos. 25, 26, 27, 28, and 29 are some of the sections I have introduced with thinner and broader heads to insure fine structure, as the rails are made by the present rapid methods.

The chemical composition has also been changed to one much harder than formerly, the product in these sections being tough and not brittle. In .60 carbon rails an elongation of 10 to 18 per

cent per inch is secured in the section of the rail under drop tests, often exceeding the elongation of rails much lower in carbon.

It will take many years of experience in the use of high-grade steel rails to convince some people that hard steel can be a material which is tough and not brittle, and one which, when the elastic limits are exceeded, will still elongate to any per cent before rupture.

One of the best illustrations of hard and tough structure in steel is in the modern armor-piercing projectiles. A 6-inch 100-pound conical projectile, fired with a velocity of 2,150 feet per second, striking a steel armor plate with 2,800 foot tons of energy, can be partially embedded therein and rebound with its point hardly dulled or its polish diminished.

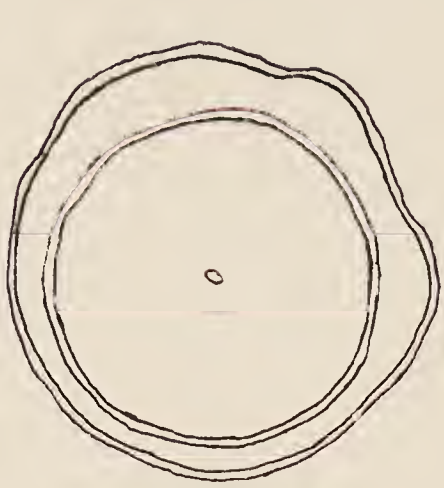
Specimen No. 30 is a piece of nickel armor plate steel of fine structure, the tensile strength averaging over 200,000 pounds per square inch, with a limited elongation of 1 to 2 per cent. Only half of this tensile strength is obtained in thick armor plates.

The size and character of the grain in rail steel is a matter of vital importance for the safety and economy of railroad operations. It is the fine texture of the steel rail which has rendered possible the development of our railway system to 163,000 miles of main tracks and 45,000 miles of sidings. In 1890, 1,100,000 tons of steel rails were put into railway tracks, and 3,125,000 tons used for structural purposes. It is hardly a quarter of a century since Bessemer-steel rails were first used to replace iron rails, and in this brief time oceans and continents are crossed, and the nations of the globe are in touch through the fine structure of steel.

LIST OF SPECIMENS.

1. Compressed steel for ordnance, from ingot.
2. Test bar from same steel after the hydraulic forging.
3. Test bar from same steel after heat treatment.
4. Specimen of etched steel from No. 1.
5. Specimen of etched steel from No. 2.
6. Specimen of etched steel from No. 3.
7. Specimen of etched steel from Bessemer rail ingot.
8. Piece of Bessemer rail ingot.
9. Piece of Bessemer rail ingot, showing pine-tree crystals.

10. Columnar structure of exterior portion of the ingot.
11, 12, 13. Webs and flanges of broken rails, showing texture of the metal.
14. Flanges of a .60 carbon rail, showing an elongation of 18 per cent per inch.
15, 16, 17, 18, 19. Sections of pit-test ingots, showing the gas bubbles, blow holes, and piping.
20. Section of worn 72-pound rail from outside of curve.
21. Section of worn 72-pound rail from inside of curve.
22. Section of unworn 72-pound rail.
23. Section of worn 63-pound rail from tangent.
24. Section of worn 63-pound rail from tangent.
25. Section of 70-pound rail, thin, broad head.
26. Section of 75-pound rail, thin, broad head.
27. Section of 80-pound rail, thin, broad head.
28. Section of 95-pound rail, thin, broad head.
29. Section of 100-pound rail, thin, broad head.
30. Section of 105-pound rail, deep, narrow head.
31. Specular iron ore.
32. Hematite iron ore.
33, 34. Octahedral crystals of magnetite.
35. Spiegeleisen.



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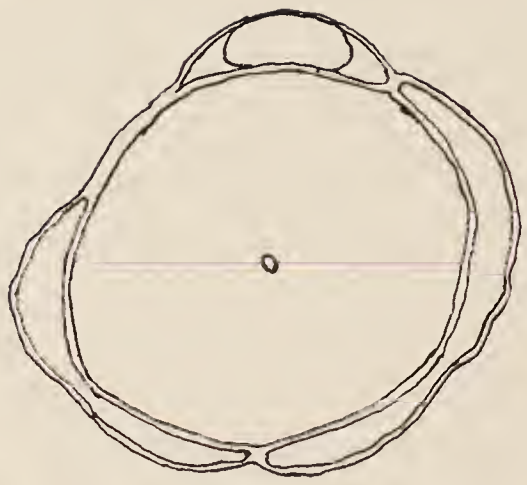

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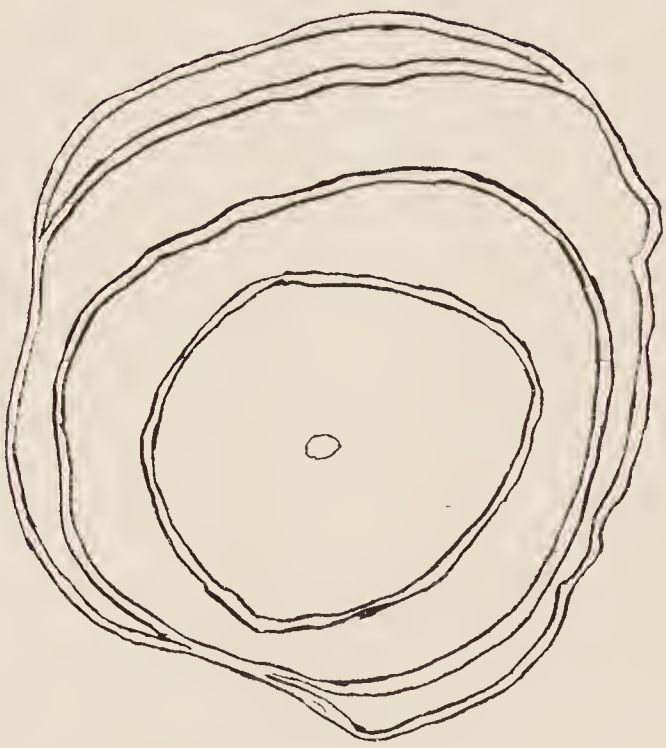

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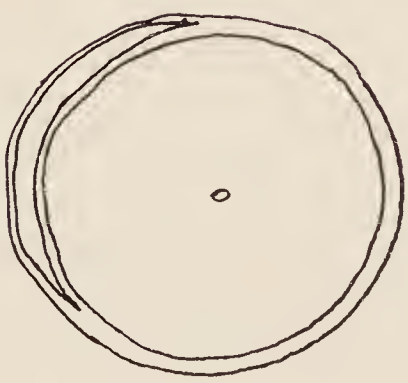

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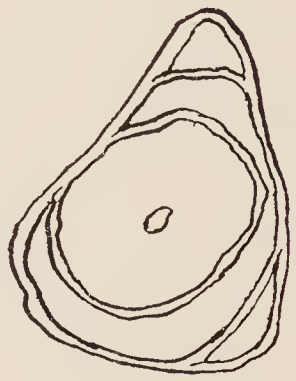

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CURTISS ON WISTARIA.

THE ANATOMY OF THE STEM OF WISTARIA SINENSIS.

BY CARLTON C. CURTISS.

(*Read May 6th*, 1892.)

About a year ago Dr. N. L. Britton received a letter calling his attention to the growth of the *Wistaria sinensis*, and asking an explanation of the apparently anomalous development. Under his direction some study has been given to the anatomical features of the plant with a view to the solution of this question. A gross examination of the anatomy of a transverse section of the older stems (Fig. 1) shows at once a deviation from the normal growths of the phanerogams, but the deviation is not apparent in the younger stems. In the latter the orientation appears normal, the products of the plerom, periblem, and dematogen being perfectly developed and presenting regular growth. For several years, usually twelve or more, this continues, after which time a new cambium zone is formed outside the primary bast and the old cambium dies. Growth now continues normally for a series of years, usually not more than eight. In all cases examined the duration of this secondary growth was several years less than that of the primary. In time this secondary cambium dies and a new one arises with the usual increase as mentioned above. This method of development continues through life, stems twenty-five years old showing four or more bast zones. In stems, however, which have been subjected to pressure while growing and thus have had their symmetrical development checked, the secondary cambium zone appears at a much earlier age, even at the end of the fourth or fifth year.

Such are the apparent features of the plant. A microscopical

Explanation of Plate 33.

FIG. 1. Cross-section of a stem of *Wistaria sinensis* thirty years old, showing three and portions of a fourth zone of bast.—FIG. 2. Cross-section of a six-year-old stem, interlocked with other branches.—FIG. A. Stem twelve years old, showing the beginning of the anomalous growth.—FIG. B. Same stem thirty centimetres below A, showing complete formation of a new cambium.—FIG. C. Cross-section of a seventeen-year-old stem, much twisted and compressed. All the figures natural size.

examination of its anatomy will make more apparent the law of growth and explain somewhat its cause. Beginning, then, with the pith, the structure in no way differs from normal dicotyledons. The cells are hexagonal and arranged in longitudinal rows The faces are approximately equal and finely pitted. The annual growth produces little displacement in the cells—at least no radical distortion. Numerous resin canals traverse the pith. These passages seem due to absorption of the contiguous cell walls, their length varying from a single cell to an indefinite number. The products of assimilation largely disappear by the end of the second year, though in older stems the pith sometimes appears heterogeneous. The pith finally becomes dark colored, partly from the infiltration of dyes from the duramen, but largely from degradation of tissue. At the periphery of the pith the cells grow smaller, thicker, and become elongated longitudinally, forming a well-marked medullary sheath. Projecting into this sheath appear numerous bundles of tracheids, the nucleus of the fibro-vascular bundles; a radial section through one of these bundles often showing from ten to fourteen of these small, delicate-walled vessels, with right-hand spirals rising in exceptionally regular and easy ascent. These tracheids appear rarely in the wood. They are at once recognized by their small size (12 μ, with a length of 150 μ), and by the fact that the septa always join the lateral walls at right angles.

In discussing the elements of the xylem Sanio's classification will be followed. Though somewhat empirical, it furnishes a nomenclature more readily followed and understood than De Bary's or Sachs'. The tissue presents the forms found in many dicotyledonous woods—pitted vessels, spiral tracheids, libriform tissue, and bundle parenchyma (Figs. 5, 6, 7, and 8). These drawings, while *ad naturam delineatæ*, are intended simply to illustrate the characteristic features of the stem, all repetition of the same tissue and anatomical detail being omitted for clearness. The cambium tissue indicated at M is composed of lenticular cells perhaps more regular than here represented, being distorted somewhat in cutting. The differentiation of the cambium seems to follow no law. Bundles of the various elements are found irregularly associated. Usually arrayed in radial groups in the annual growth, they rarely present the same combination of

bundles for a series of years. During the first and second years the libriform tissue composes the bulk of the fundamental mass; in the succeeding annual zones it diminishes and may nearly disappear, being replaced by tracheids and vessels. The spiral tracheids figured at T are perhaps the most abundant tissue in the plant. Retaining their original cambium form, they illustrate especially well the transition from tracheid to vessel. If they exist as vessels their irregular course indicates at once where the septa were, as at X. As noted above, they differ from the spiral tracheids of the medullary sheath in their large and thickened walls, while the spirals often branch and the vessels become pitted (Fig. 9). No measurements will be given when the individual element is figured, the illustrations being designed to represent the average size of the cells. The pitted vessels, a small one of which is figured at V, are the most noticeable of the individual elements, being easily seen with the eye, and usually forming, after the sixth year, the bulk of the wood. They have much the same arrangement as in the *Quercus rubra*, the concentric circles seemingly confined to the autumn wood and figuring sparingly in the denser portions. The size of the ducts varies; comparatively small in the first zone, they increase annually and reach their maximum growth in from eight to ten years, often having a diameter of from 300 to 400 μ. The walls are much pitted with discoid markings. Fig. 10 represents a vessel separated by Schultze's fluid and viewed from without. The halos seem to be oval, arranged in rows, and alternating in the rows with one another. The canals are narrow slits, usually extending quite across the disc, and are partially concealed by the thickening membrane of the vessel. Tyloses is the rule with these vessels. The walls of the intruded parenchyma often become much thickened and pitted. The frequency is probably due to the fact that parenchyma usually borders these vessels, and the numerous slits afford it an easy ingress. These large and numerous tubes serve important mechanical ends in giving lightness and strength to the plant. A rough measurement of a cross-section places the area of the tubes as one-third that of the plant.

The wood parenchyma shows at P. In the variation of its dimensions and form it well exemplifies its name—*parenkeo*. The cells are irregularly pitted when contiguous to vessels or medul-

lary rays, and show a slight tendency to border pits when adjoining elements so marked. At I another very common form is shown. These latter cells would correspond to Sanio's intermediate tissue, in that they are libriform, contain food, and have all the characteristics of parenchyma; but in no case could oblique, slit-like markings be found. The libriform tissue, L, affords excellent examples of sclerenchyma. The cells appear stratified, showing a lignified outer wall, a thicker middle layer, and a homogeneous gelatinous inner layer (Fig. 11). The fibres often appear filled with the granular residue of the cell contents. In no case examined did they show striation or pitting. In the first year their growth appears very regular, but thereafter the ends extend themselves at sharp angles radially and tangentially. Thus the wood offers much resistance to splitting along any plane and gives great toughness to the vine.

The medullary rays extend in uni- or multi-seriate radial rows through the wood, the wider bands extending to the pith, while narrow ones appear between, formed each succeeding year as the dilatation of the stem continues. In tangential section their mode of origin from the cambium cell is evident. Considering now the phloem, it will be seen to be composed of bundles of sclerenchyma alternating with rows of parenchyma and sieve tubes. The regularity of this arrangement is often interrupted by the unequal growth of the parenchyma and the dilatation of the medullary ray. The sclerenchyma, B, resembles closely the fibres of the xylem. They exceed it, however, in length, but not in thickness (Fig. 13). The outer layer is less lignified than that of the wood, while the cartilaginous layer is greatly developed, often filling irregularly the entire lumen. Apparently there is no middle lamina (Fig. 14). Scattered through the sclerenchyma are fibres containing crystals. These septate cells were not without occurrence in the wood, especially in the older zone. In the bast they appear the first year and become at once its most pronounced feature. These crystal-bearing fibres seem to arise directly from the cambium, and have the general form of the bast. After the formation of the crystals each is separated by transverse divisions of the fibre. From twenty to thirty of these crystals appear in a fibre, each chamber being nicely proportioned to the size of the crystal. The fibres are not lignified,

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CURTISS ON WISTARIA.

the walls remaining exceedingly delicate and transparent. Crystals appear in this delicate cellulose sack, embedded in a gelatinous medium which completely fills the chamber. About the crystal is a film which on treatment with iodine shows the reaction of cellulose (Fig. 15). The crystals belong to the monoclinic system, though the corners are often blunted and irregular forms result (Fig. 16). Crystals also appear irregularly scattered through the parenchyma. With the sclerenchyma alternates the soft bast, S. With the pressure of growth these cells are much distorted, and the delicate sieve tubes are so much compressed as to lose all trace of structure and perhaps entirely disappear. These tubes, in the cases where examination is possible, appear in the parenchyma adjoining the liber fibres, and thus correspond to the annual zones. Their lateral walls seem to be destitute of plates and the cribrose septa are nearly horizontal. They greatly exceed the parenchyma in length, but have about the same transverse measurements. These bundles of parenchyma and sclerenchyma correspond closely and, I believe, exactly with the annual zones of the wood; the outer ones being compact, with an excess of fibre, while the inner bundles of the phloem are generally characterized by an absence of fibre and the soft bast is multiplied to several layers, giving a loose structure. This development presents a striking parallel to the dense heart growth of the xylem and its later light structure. A marked characteristic of the phloem is the presence of resin receptacles. These are arranged in concentric circles following the parenchyma in its growth, but never appearing in the medullary ray. As viewed in cross-section they occupy from one to several cells and give a banded structure to the bast. The resin has the appearance of gamboge. It is an exceedingly inert mass, little affected by strong acids, and slowly dissolves in

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Explanation of Plate 34.

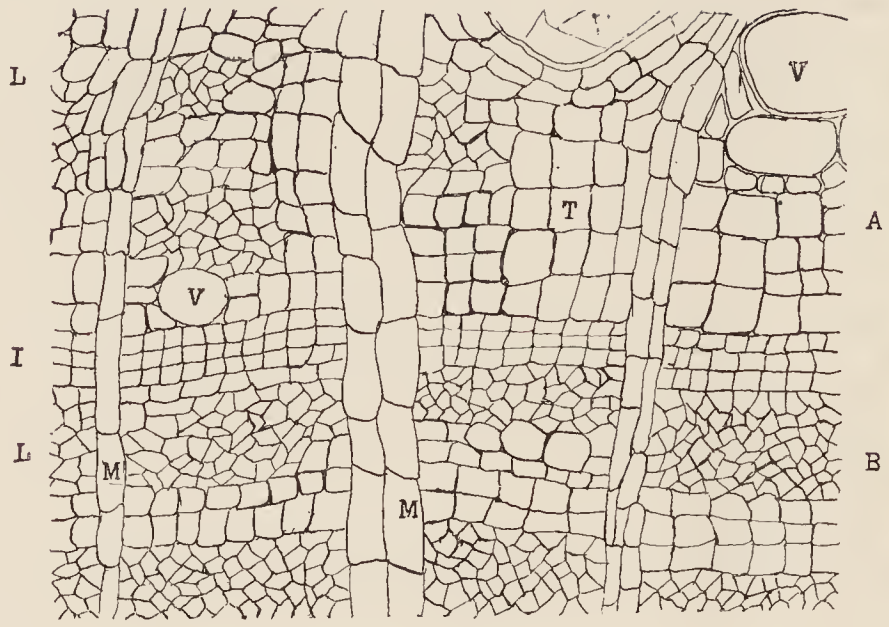
FIG. 5. Cross-section of stem. E, cork; K, parenchyma of periblem; C, cortical sheath; R, resin sack; B, bast fibre; F, crystal fibre; S, parenchyma of the bast; M, cambium tissue; T, a portion of three tracheids, showing at X an absorbed septum; V, trachea with tyloses, and a portion of its pitted wall; P and I, forms of wood parenchyma; L, liber fibre. × 500.—FIG. 6. Cross-section of stem lettered as in Fig. 5. D, medullary ray. × 300.—FIG. 7. Tangential section lettered as in Fig. 5, showing a layer of much thickened cork cells with pits. × 500.—FIGS. D and E. Radial and cross-sections of medullary ray, showing pitted walls. × 500.

Schultze's solution, losing its orange color and disappearing as an amber fluid. It is not improbable that this gum has the medicinal properties of gamboge, as Ottow found a poisonous glucoside in the bark of the *Wistaria*. Mention is not made of the properties of this poison, and it may have no connection with the resin, which does not occur in the bark. The latter term, however, may have been loosely used to include the inner cortex. The origin of these cells is lysigenetic. In the young bast and pith single cells of parenchyma are found filled with the resin; but with growth, either through rupture or dissolution of contiguous walls, the resin spreads, forming irregular branching passages. In the pith the resin slowly disappears before the period of degradation begins, but remains a constant feature of the phloem. The dilatation of the bast becomes very noticeable with the advance of age, forming the triangular white spots of the cortex (Fig. 17). This enlargement is brought about largely by the medullary rays, and usually by the multi-seriate ones. These broaden as they are pushed out by the successive annual zones, and by radial bipartition of the individual cells the original size of the cell is approximately maintained. These huge wedge-shaped masses of parenchyma often constitute the larger part of the bast, and so intermingle with the parenchyma of the outer cortical zone as to leave no line of demarkation between them.

Considering now the periblem, it is seen to consist entirely of parenchyma. The cells are filled with plastids containing chlorophyll, protein matter, and starch granules. These plastids are circular or lenticular in form, often showing starch embedding in or adhering to their surfaces. Fig. 18 illustrates the forms of plastids and starch granules found in the plant. The first change in this external cortical zone is the formation of the phellogenetic meristem. This takes place in the external layer of cells during the first year (Fig. 19). The development at first is entirely centripetal. Of the two cells formed by the first division, the outer one eventually becomes cork, while the inner one continues to grow and again divides, the inner one ever remaining active. But after the fourth or fifth year the development changes and becomes reciprocal. Now the inner of the cells formed by the division of the mother cell is no longer

meristematic, but becomes the first layer of the phelloderm. With the next division of the mother cell the outer cell is added to the cork, and, thus alternating, the successive zones are formed until about eight layers of phelloderm appear, when the growth once more becomes centripetal and so continues. In the younger stems a layer of cork is added each year. This appears to continue through life, for in the periderms of older stems the layers of cork so closely correspond to the annual zones that the loss of bark would easily explain the deficit. Thus the plant seems to be exceptionally regular in the formation of all its parts. The cork cells are tabular, appearing at first with delicate walls filled with sap (Fig. 20). If complete suberification of the walls results the cell contents remain as a brown, resinous mass, filling the cell. Sanio holds that air never appears in those cells which contain this residue of cell life. But cases are not wanting in which the contents seem to have drawn away from the walls, leaving an air cavity. This separation may be due to the disturbance of the cell either from chemical reaction or cutting. In many cells the cutinization is slight, in which case the inner lamina grows to the exclusion of nearly the entire lumen and becomes much furrowed by canals (E). It is worthy of note that these thickened and brown-colored cells usually alternate, giving a marked stratified appearance to the cork. The walls are transparent, even in the oldest cells, readily showing through the green of the phelloderm. They adhere strongly by their tangential walls, and when the pressure of growth finally severs them they curl back from the break, causing the scale-like appearance of the bark. Contemporaneous with the cork-meristem appears the first trace of the cortical sheath. Certain cells of the parenchyma adjoining or near the bast begin to thicken, and eventually become short-celled sclerenchyma, the lumen being nearly excluded and the pit canals much branched (Fig. 21). A zone more or less interrupted is formed, sharply separating the plerom and the periblem. Secondary bundles often arise outside the primary groups. This element is a very characteristic feature of the outer cortex, and affords exceptionally good material for the study of the origin and the development of sclerenchyma. The dilatation of the fundamental mass of the periblem keeps pace with the growth of the stem. In so doing there is a loss in

the thickness of the cell wall until these cells resemble perfectly those of the parenchyma of the phloem. In case of the commingling of the elements in this way groups of cells are moved from the cortical sheath, and in the phloem occasionally they undergo sclerosis. In the dermatogen is found but a single uniseriate zone. Growth continues apparently during the first year only, when life is cut off by the completion of the first layer of cork. Many of the cells are prolonged into hair-like trichomes, which probably assist the stoma in supplying the plant with air. No intercellular spaces occur save where stomata are formed. The cells are nearly rectangular, their superficial walls being much thickened and completely cutinized. They contain colorless granules and sap, starch however being found in the guard cells of the stoma (Fig. 22). With the formation of the cork a change occurs in those cells below the stoma in or near the meristem. As the cork is formed these cells exceed the growth of the periderm, and thus is formed a double convex swelling which pushes up the stoma long before death ensues (Fig. 23). At the phelloderm the cells are regularly arranged in rows containing a few granules and filled with a colorless sap. Outside of these are the complementary cells, with corners more or less rounded, and in structure similar to the cork. As in the cork, some are filled with the dried remains of cell life, but, being irregularly placed among the transparent cells, they present a mottled rather than a banded structure. This mass of loose complementary tissue is held together by layers of flat cells which alternate with them. These tabular cells adhere strongly by their radial walls, but, owing to their irregular tangential surfaces, they do not interfere with the access of air to the phelloderm. These cortical pores increase with the dilatation of the periderm, attaining in transverse diameter a length of five or six millimetres. The lenticles of the older stems are abundant and apparently exceed the stoma of the younger growths, and it seems not improbable that they are often formed under the trichomes which thickly beset the epidermis. In looking over the literature on the *Wistaria*, as noted in the *Botanischer Jahresbericht*, I find only incidental references made to it, as already noted. Both De Bary and Sachs, in their "Handbook of Physiological Botany," relying largely on the examinations of Eichler, Crüger, and Müller, place the origin



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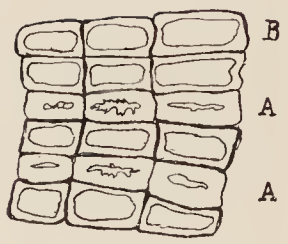

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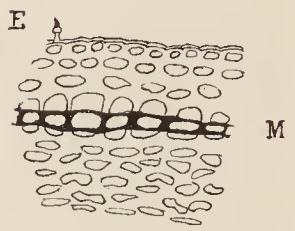

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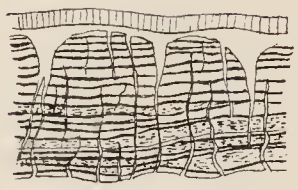

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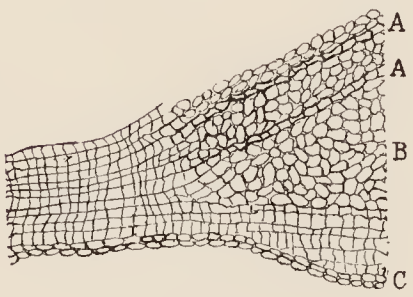

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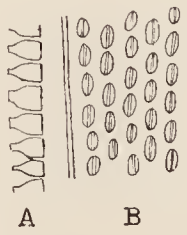

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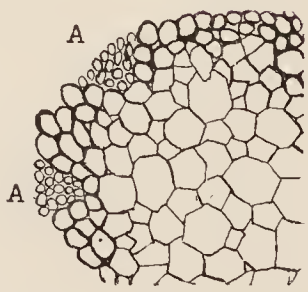

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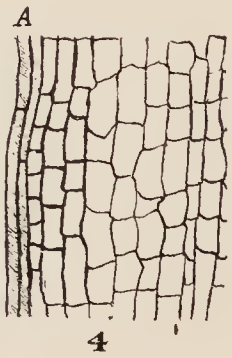

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of the successive rings of thickening in the older zones of the secondary bast. From examination of many sections taken from stems varying in age from four to twenty-five years, it seems impossible that the conclusions of the authors mentioned can be correct. The law may be true for the lians, with which they chiefly worked, and it is possible that the *Wistaria*, under different conditions of climate and soil, may conform to the above law. The cortical sheath of the *Wistaria* gives an unmistakable landmark by which to locate growth. This is always near the periblem and plerom boundary. No amount of it is found in any other place. If De Bary's position were true this sheath could never appear in the phloem that has been cut off externally by wood. It would ever be pushed out with the periblem by the new growth. But not a section of the interstratified phloem has been examined that does not reveal the cortical sheath on the periphery of the bast. It may be advanced that with the formation of the new cambium dilatation of the adjoining parenchyma and sclerosis follow. In this case the process could easily be noted, and, secondly, the dilatation would present features distinct from that manifest in stems where growth is yet normal. As a matter of fact, the structure of the included bast zones differs in no respect from that of the regular growth. The same widening of the medullary ray, and the completed sclerosis, etc., are always present. Again, in sections taken from the angles formed by the commingling of two bast zones, the sclerosis is seen to curve

Explanation of Plate 35.

FIG. 3. Cross-section of pith, showing fibro-vascular bundle, A, in the medullary sheath. × 200.—FIG. 4. Radial section of pith. A, spiral tracheids. × 200.—FIG. 8. Cross-section of xylem, showing A, autumn growth, and B, denser wood. × 500.—FIG. 9. Tracheid with anastomosing spirals. × 500.—FIG. 10. A, longitudinal section of tracheæ, showing forms of pits and canals ; B, transverse view, showing the thickening portion encroaching upon the slit-like canals. × 500.—FIG. 11. Cross-section of liber fibres, showing stratification. × 500.—FIG. 12. Liber fibres separated by maceration. × 66.—FIG. 13. Bast fibres separated by maceration. × 66.—FIG. 14. Bast fibres, cross-section showing two layers. × 500.—FIG. 15. Three sacks of the crystal fibre swollen by maceration. × 500.—FIG. 16. Crystal forms. × 500.—FIG. 17. Cross-section of inner and outer cortex, showing the dilatation of the medullary ray. The heavy horizontal lines and the dotted spaces represent the relative amounts of parenchyma in the bast. × 12.—FIG. 18. Plastids and starch granules. × 500.—FIG. 19. Cross-section of stem, showing the cork meristem in the third layer of cells, and the epidermis with trichome, E. × 300.—FIG. 20. Cross-section of cork cells. A, A, the much-thickened cells ; B, those completely suberized. × 500.—FIG. 21. Short sclerenchyma. × 500.—FIG. 22. Stoma of stem. × 300.—FIG. 23. Lenticle. A, A, tabular cells radially joined to retain in place the loose cells ; C, phelloderm. × 200.

around from the outer bast in a clearly marked line to the outer periphery of the included bast. But one explanation can account for this, namely, that the new zone of growth arises in the periblem near the cortical sheath. Here, moreover, are all the elements necessary for growth—a living parenchyma rich in chlorophyll, starch, and protein matter. Only in a single stem was this growth seen to be in process. In this case the cambium seems to have risen on a line with the cortical sheath, for the wood fibres were interrupted by the bundles of sclerenchyma. This may be the place of new growth, since in removing the inner cortex from the wood the line of separation is always dentate, which outline the sclerotic bundles crowding into the wood tissue would exactly produce. It is not always apparent, however, that the dentation is due to this mode of development. The cause of the anomalous growth is doubtless due to pressure. As the annual zones are pushed out greater and greater resistance is offered to radial extension by the bast. The sinuous course, in the older stems, of the medullary ray would be indicative of this, but it is to be noted that the irregularity is almost entirely confined to the corrugated, gnarled stems and therefore is in great measure due to torsion. The radial distortion of the parenchyma and the collapse of the sieve tubes indicate more strongly the pressure of growth. Finally, as regards the fact that the secondary growths are less than those of the primary, it may be held that the plant reaches its maturity at about the twelfth year. Now the potential of the plant life is lower, new elements are added with less vigor, and consequently it can force back the bast for a shorter period.

Reviewing the elements of the stem, one cannot fail to be impressed with the wonderful regularity, economy, and fitness manifested in the arrangement of the tissue. The xylem, phloem, and periblem each receives its proportional annual increase, developing all its parts with a precision truly wonderful. The tough strands of the sclerenchyma were needed at first to give a strong rope of support to the vine with its heavy foliage ; but with the advance of age the complement of this was needed, lightness as well as increased facilities for the transmission of food. Now appear the larger elements—the tracheæ, hollow cylinders of support, made more light by their sculptured walls, while the tracheids with their thickened walls afford a

roadway for the rapid transmission of food. From an eighteen-year-old stem a quarter-section was taken, so as to secure all the elements in their relative proportion. From this the specific gravity was found to be only two and a half times that of cork. Thus at once is secured a stem of great strength and unusual lightness. But truly the most wonderful element is the bast, so fine that J. J. Rein, in a paper on the textile plants of Japan, credits the Japanese with attempting its manufacture into linen. This seems very feasible, for the elements have a diameter of 12 μ and reach a length of 230 μ, in appearance and measurements corresponding closely with *Linum usitatissimum* (Fig. 13). In their strength they exceed all the other elements of the stem. From some rather unsatisfactory tests of the sustaining power of the bast it was found that a piece two millimetres wide and one millimetre thick would sustain a weight of twenty-two and seventy-three hundredths kilos, more than one-fifth of the sustaining strength of soft iron. Here again the adaptability of the plant to its mode of life is manifest. The strength of the bast cylinder alone would doubtless be sufficient to meet all strains brought to bear upon it; but considering the older stems, often surrounded by several concentric cylinders, the strongest form of structure possible, the utility of the arrangement to the plant is obvious. At the low estimate given above, an old stem before me showing three bast zones would have a sustaining power of over half a ton. There now remains for consideration the life of the plant—by no means its least interesting feature. For in the adaptation of its growth to meet the strain laid upon it, there arose in the bast such a barrier to development that the life of the plant must cease or the restraint be overcome. And so, to secure to itself at once its element of strength and life, the barrier wall is left unbroken and life begins anew beyond the bast and without restraint.

PROCEEDINGS.

Meeting of February 19th, 1892.

The President, Mr. J. D. Hyatt, in the chair.

Sixty persons present.

Prof. Samuel Lockwood, Ph.D., addressed the Society on "The Blood after Electrocution." This address referred especially to the appearances of the corpuscles of the blood of Kemmler, the first victim in the State of New York of the infliction of the death penalty by means of the electric current.

Dr. Lockwood maintained that the condition of the red corpuscles of the blood, taken from the head of the victim in the direct path of the current five minutes after electrocution, shows the effect of the dreadful shock. "Here is an exhibit of an astonishing catastrophe. In no instance has a single corpuscle escaped damage. All are reduced fully one-third in size. Many of them look as if they were smashed. From some the protoplasm exudes like the pulp from a crushed grape. Many are reduced to mere granules, and distortion is general."

The address was illustrated by lantern projections of photomicrographs of blood corpuscles from various animals, from normal human blood, and from Kemmler's blood, and also by preparations under microscopes as indicated below.

Objects exhibited.

1. Blood of Frog.
2. Blood of Alligator.
3. Blood of Pigeon.
4. Blood of Dog.
5. Normal human blood.
6. Kemmler's blood, from the thigh.
7. Kemmler's blood, from the head.

All by Samuel Lockwood.

Meeting of March 4th, 1892.

The President, Mr. J. D. Hyatt, in the chair.

Fifteen persons present.

OBJECTS EXHIBITED.

1. *Navicula trinodis*, from Ashbourne, Pa.

2. *Coscinodiscus excavatus*, from artesian well at Beach Haven, N. J.

3. *Triceratium* (new species), from the same.

Exhibits 1–3 prepared by Dr. C. Henry Kain and exhibited by E. A. SCHULTZE.

4. Wood fibre from coal, Deer Creek, Walker Co., Ala.

5. Sporangia from the same.

6. Macrospores from shale, Ontario, Canada.

Exhibits 4–6 prepared by K. M. Cunningham and exhibited by GEO. E. ASHBY.

MEETING OF MARCH 18TH, 1892.

The President, Mr. J. D. Hyatt, in the chair.

Fourteen persons present.

OBJECTS EXHIBITED.

1. Serial sections of the fish, *Atherina* sp. (Silversides), through the gills: by L. RIEDERER.

2. Serial sections of the same, through the head: by L. RIEDERER.

3. Serial sections of the same, through the eye: by L. RIEDERER.

4. Malachite, from Arizona: by GEO. E. ASHBY.

5. Brucite, from Hoboken, N. J.: by GEO. E. ASHBY.

6. Sea-sand, mounted movable in fluid: by J. D. HYATT.

7. Fresh-water Diatoms, from Montgomery, Ala., prepared in monobromide by Dr. Ward, of Poughkeepsie: by J. D. HYATT.

8. Pigeon-post film, used in the siege of Paris: by J. D. HYATT.

9. Twenty-five Photomicrographs of various preparations: by FRANK D. SKEEL.

MEETING OF APRIL 1ST, 1892.

The President, Mr. J. D. Hyatt, in the chair.

Forty persons present.

Dr. Carl Heitzmann addressed the Society on "Fallacy of the

Cell-Theory." This address was illustrated by microscopical preparations as stated below.

OBJECTS EXHIBITED.

1. Cornea of Cat, with basis substance stained with chloride of gold showing reticulum.

2. Cornea of Cat, stained with nitrate of silver.

3. Section of human tooth with silver amalgam, showing reticulum in the dentine.

4. Dentine of human tooth, showing effect of amalgam.

All by DR. CARL HEITZMANN.

MEETING OF APRIL 15TH, 1892.

The President, Mr. J. D. Hyatt, in the chair.

Fifteen persons present.

OBJECTS EXHIBITED.

1. Aventurine Feldspar (Sunstone), from Sussex Co., N. J.: by JAMES WALKER.

2. Section of the same by polarized light: by JAMES WALKER.

3. *Megalotrocha.*—Rotifer colony—illustrating a convenient method of transportation and exhibition: by JAMES WALKER.

Mr. Walker explained the ingenious and convenient method of handling the colony of Rotifers exhibited by him. A microscopical cover glass is attached to one end of a thread by means of a minute piece of wax. The cover glass is suspended in the water of an aquarium. The thread passes over the edge of the aquarium, and at the end, hanging outside, a balancing weight, consisting of a small shot or any other convenient minute object, retains the cover glass in any desired position in the water. When a colony has attached itself to the cover glass, glass and colony can be transported by transferring them uninjured to a bottle of water, and they can be conveniently retained in any position for examination on the stage of the microscope by transferring them from the bottle to a stage tank.

Mr. Walker also described the piece of apparatus, constructed by himself, for revolving the polarizing prism on the microscope. A small shaft is attached to the substage, carrying at one end a

milled head, slightly projecting beyond the microscope stage, and having at the other end a pinion engaging in a crown-wheel, fastened to the tube containing the prism.

Annual Exhibition, April 22d, 1892.

The Thirteenth Annual Exhibition of the Society was held at the American Museum of Natural History, Central Park, New York City, on the evening of April 22d, 1892.

The objects exhibited, as noted in the programme below, were displayed in the large hall of the first floor of the Museum. During the evening there were three exhibitions of thirty minutes each in the spacious Lecture Room adjoining, as follows: At 8 clock—Exhibition of Lantern Slides of Photomicrographs, by E. G. Love. At 9 o'clock—Exhibition of Lantern Slides of Diatoms, by C. F. Cox. At 10 o'clock—Exhibition of Microscopic Objects with polarized light by E. C. Bolles.

PROGRAMME.

1. Old Microscopes and Accessories (Alcove No. 1). Loaned by C. F. Cox, J. L. Zabriskie, Wm. Wales, F. D. Skeel, L. Schöney, and the American Museum of Natural History: by Wm. Wales.

2. Method of Grinding and Mounting Lenses for the Microscope (Alcove No. 1): by Wm. Wales.

3. Transverse Section of the Pad of a Cat's Foot, showing "touch" corpuscles: by Geo. E. Ashby.

4. Saws of Rose Saw-fly: by Geo. E. Ashby.

5. Transverse Section of the Stem of Cycas revoluta: by Geo. E. Ashby.

6. Revolving Stage with eleven objects: by Thos. Taylor.

7. Sponge Spicules, Barbadoes: by E. J. Wright.

8. Crystallized Zinc Oxide: by Frederick Kato.

9. Hydromagnesite, Hoboken, N. J.: by J. W. Freckelton.

10. Sunstone, a variety of Feldspar, Sussex County, N. J.: by A. H. Ehrman.

11. Arachnoidiscus in situ on Seaweed: by F. E. Bloodgood.

12. Microphotograph, The Madonna, Raphael: by A. Woodward.

13. Crystals of Chlorate of Potash, with polarized light: by A. WOODWARD.

14. Scales of Morpho Butterfly from Brazil: by WM. BEUTENMÜLLER.

15. Section of Cornstalk: by WM. BEUTENMÜLLER.

16. Vinegar Eels, living: by ALFRED BEUTENMÜLLER.

17. The Oyster, examined microscopically and otherwise (Alcove No. 2): by GEO. W. KOSMAK.

18. Bouquet made from Butterfly Scales: by E. A. SCHULTZE.

19. Arranged Diatoms from Santa Monica, Cal.: by E. A. SCHULTZE.

20. Stellate Hairs on Leaf of Deutzia scabra, with polarized light: by J. L. WALL.

21. Pollen Grains of Lavatera in situ: by H. C. BENNETT.

22. The Diamond Beetle, *Entimus imperialis:* by M. H. EISNER.

23. Silicious Cuticle of Equisetum, with polarized light: by M. H. EISNER.

24. Case for Microscope and Accessories, made of mother-of-pearl: by M. H. EISNER.

25. Cutting, Staining, and Mounting of Serial Sections by the Paraffin Process (Alcove No. 3): by L. RIEDERER.

26. Section of the Abdomen of a Dragon-fly: by L. RIEDERER.

27. Transverse Sections of the Tongue of a Butterfly, *Colias Philodice:* by L. RIEDERER.

28. "Sea Spider," *Phoxichilidium:* by L. RIEDERER.

29. Chromatophores or Pigment Cells in skin of common Shrimp, *Crangon vulgare:* by HEINRICH RIES.

30. Red Earth-mite, *Trombidium:* by WM. HUCKEL.

31. Yellow Ochre, pseudomorph after Siderite, New York City: by JAMES WALKER.

32. Sections of Dumortierite in Orthoclase, Oligoclase, Fibrolite, Serpentine, Scapolite, and Mica with inclusions, shown with automatic revolving stage and polariscope: by JAMES WALKER.

33. Specimens illustrating successive stages in Grinding and Mounting Rock Sections: by JAMES WALKER.

Microphotography (Alcove No. 4), Apparatus and Slides : by S. N. AYRES :

34. Bird's-eye View of the Columbian Exposition.
35. The Dream of Pharaoh's Wife.
36. Portrait of Child.
37. Foes or Friends.

38. Influenza Microbes: by L. SCHÖNEY.
39. Trichinæ Spiralis in Human Muscle: by J. A. GOTTLIEB.
40. Photomicrographs : by J. A. GOTTLIEB.
41. Cutting, Grinding, and Mounting of Rock Sections (Alcove No. 5) : by J. D. HYATT.
42. Section of Agate, with polarized light : by J. D. HYATT.
43. Vibratile Cilia of Mussel, *Mytilus :* by J. D. HYATT.
44. Circulation of Blood in a Frog's Foot : by J. D. HYATT.
45. Porpita Linnæana, a Hydrozoan, allied to the Portuguese Man-of-war : by L. P. GRATACAP.
46. Pond Life : by THOS. CRAIG.
47. Skin of Leptosynapta, showing Anchors and Plates : by W. C. KERR.
48. Section of Scotch Coal, Stigmaria : by H. W. CALEF.
49. Fern-leaf Crystals of Gold : by G. S. WOOLMAN.
50. Head of Mosquito : by G. S. WOOLMAN.
51. Human Blood on Holman's Slide : by F. H. LEGGETT.
52. Circulation in Nitella : by F. W. DEVOE.
53. Circulation in Vallisneria : by F. W. DEVOE.
54. Crystals obtained from the Blood of a Caterpillar, with polarized light : by SAMUEL LOCKWOOD.
55. Native Crystallized Gold, Colorado. Slide mounted with removable cover glass : by A. H. CHESTER.
56–59. Pond Life, including the following forms recently discovered by the exhibitor : *Lagotia cæruleus*, *Urnatella Walkerii*, *Octocella libertas*, and *Cordylophora coronata* (Alcove No. 6) : by STEPHEN HELM.
60. A Series of Drawings of the Lower Forms of Animal Life (Alcove No. 6) : by STEPHEN HELM.
61. Head of a Tape Worm : by MISS M. V. WORSTELL.
62. Luxullianite, with polarized light: by MISS M. V. WORSTELL.
63. Hydroid, Obelia, showing Polypites, Gonophore, and attached Diatoms : by G. S. STANTON.

64. Iodo-Sulphate of Quinine, with polarized light: by GEO. M. HOPKINS.

65. Autograph of the Electric Spark: by GEO. M. HOPKINS.

66. Arranged Group of Diatoms, illuminated by Parabola: by C. F. COX.

67. Crystals of Quinidine, with polarized light: by C. F. COX.

68. Trichomes and Transverse Section of the Leaf of the Long Moss, *Tillandsia usneoides* L., from Florida, with polarized light: by J. L. ZABRISKIE.

69. A new Microscope Lamp: by J. L. ZABRISKIE.

70. Photomicrographic Apparatus with Photomicrographs (Alcove No. 7): by E. G. LOVE.

71. Palate of Whelk, *Buccinum undatum*: by E. G. LOVE.

72. Section of the Ovary of Indian Pipe, *Monotropa uniflora*: by E. G. LOVE.

73. Section of Echinus Spine, *Echinometra lucunter*, with polarized light: by E. G. LOVE.

74. Finest Manchester Muslin: by E. G. LOVE.

75. Human Hair from Beard: by E. G. LOVE.

76. Suction Cup from Arm of Devil-fish, *Architeuthis princeps*: by WM. E. DAMON:

77. Skin of Sole: by W. H. MEAD.

78. The Ruby: by GEO. F. KUNZ.

Etchings of Steel, showing Structure (Alcove No. 8): prepared by P. H. DUDLEY and exhibited for him by THOS. B. BRIGGS:

79. Exterior columnar Structure of a .50 per cent carbon Bessemer Rail Ingot.

80. A .26 per cent carbon Bessemer Rail Head, which is so coarse that it wears rapidly under heavy traffic.

81. A good low-carbon Rail, the carbon being nearly all combined.

82. Dense Structure of a .60 per cent carbon Rail.

83. A 3 per cent nickel Armor-plate Ingot.

84. Ordnance .40 per cent carbon steel, after hydraulic forging.

85. Photomicrographs showing structure of steel.

86. Section of Retina of Human Eye, showing Rods and Cones: by F. D. SKEEL.

87. Section of Human Eye, showing cancerous growth (*Melano-sarcoma*): by F. D. SKEEL.

88. Cheese Mites, *Acarus domesticus:* by W. D. MACDONALD.

89. A Series of Photomicrographs, made by the late DR. J. J. WOODWARD (Alcove No. 9): by C. F. COX and E. G. LOVE.

90. Polycystina, Barbadoes: by H. F. CROSBY.

PUBLICATIONS RECEIVED.

The American Monthly Microscopical Journal: Vol. XIII., No. 3—5 (March—May, 1892).

The Microscope : Vol. XII., Nos. 3—5 (March—May, 1892).

Bulletin of the Torrey Botanical Club: Vol. XIX., Nos. 4—6 (April—June, 1892).

Journal of Mycology : Vol. VII., No. 2 (March, 1892).

Anthony's Photographic Bulletin: Vol. XXIII., Nos. 6—10 (March 26—May 28, 1892).

West American Scientist : Vol. VIII., No. 64 (March, 1892).

Natural Science Association of Staten Island : Proceedings of March 12—May 14, 1892.

San Francisco Microscopical Society : Proceedings of March 16—April 20, 1892.

Psyche : Vol. VI., Nos. 192—194 (April—June, 1892).

Seventh Report on Injurious Insects of New York, Dr. J. A. Lintner (1891).

Insect Life : Vol. IV., Nos. 7, 8 (April, 1892).

Journal of the Elisha Mitchell Scientific Society: Vol. VIII., Part 2 (July, 1892).

Massachusetts Horticultural Society, Transactions, 1890, Part 2 : Schedule of Prizes (1892).

Transactions of the Wisconsin Academy of Sciences, Arts and Letters: Vol. VIII. (1888—91).

Transactions of the Academy of Science of St. Louis : Vol. V., Nos. 3, 4—Vol. VI., Nos. 1, 2 (1888—April, 1892).

Proceedings of the Academy of Natural Sciences of Philadelphia : 1892, Part 1.

Bulletin of the Essex Institute : Vol. XXIII., Nos. 1—3 (January—March, 1892).

School of Mines Quarterly : Vol. XIII., No. 3 (April, 1892).

Agricultural Experiment Station of Michigan : Bulletins 81—85 (March, April, 1892).

Agricultural Experiment Station of Alabama : Bulletins 36, 37 (March, 1892).

Agricultural Experiment Station of Iowa : Bulletin 16 (February, 1892).

Agricultural Experiment Station of Texas: Bulletin 20 (March, 1892).

Laboratory of Denison University, Bulletin : Vol. VI., Part 2 (January, 1892).

The Species of Rumex occurring North of Mexico, William Trelease (April, 1892).

Ottawa Naturalist : Vol. VI., Nos. 1, 2 (May, June, 1892).

Canadian Record of Science : Vol. V., Nos. 1, 2 (January, April, 1892).

Historical and Scientific Society of Manitoba ; Annual Report (1891): Seven Oaks (1892) : Geology of Red River (1892).

Grevillea : Vol. XX., Nos. 95, 96 (March, June, 1892).

Journal of the Royal Microscopical Society, 1892, Part 2.

International Journal of Microscopy and Natural Science : Vol. II., Part 14 (April, 1892).

The Naturalist : Nos. 201, 202 (April, May, 1892).

The Victorian Naturalist : Vol. VIII., Nos. 10, 12 (February, April, 1892).

Royal Society of South Australia, Transactions and Proceedings: Vol. XVI., Part 2 (December, 1891).

Records of the Australian Museum, Index of Vol. I. (February, 1892).

Brooklyn Medical Journal: Vol. VI., Nos. 4—6 (April—June, 1892).

The Satellite : Vol. V., Nos. 8—10 (April—June, 1892).

Hahnemannian Monthly : Vol. XXVII., Nos. 4—6 (April—June, 1892).

Indiana Medical Journal : Vol. X., Nos. 10—12 (April—June, 1892).

American Lancet : Vol. XVI., Nos. 4—6 (April—June, 1892).

Johns Hopkins University Circulars : Vol. XI., Nos. 97, 99 (April, June, 1892).

The Weekly Bulletin : Vol. I., Nos. 40, 45, 46 (April, June, 1892).

Mining and Scientific Review : Vol. XXVIII., Nos. 11—22 (March—June, 1892).

National Druggist: Vol. XX., Nos. 7—11 (April, June, 1892).

Le Diatomiste: No. 8 (March, 1892).

Bulletin de la Société Belge de Microscopie: Vol. XVIII., No. 5 (February, 1892).

La Notarisia: Vol. VII., Nos. 29, 30 (February, April, 1892).

La Nuova Notarisia: Vol. III. (April, 1892).

Nuovo Giornale Botanico Italiano : Vol. XXIV., No. 2 (April, 1892).

Bulletin de la Société Royale de Botanique Belgique : Vol. XXXI., Part 2 (1892).

Bollettino della Società Botanica Italiana : Nos. 2—4 (1892).

Bollettino della Società Africana d'Italia : Vol. XI., Nos. 1, 2 (January, February, 1892).

Wissenschaftlicher Club in Wien : Monatsblätter, Vol. XIII., Nos. 6—8 (March—May, 1892). Ausserordentliche Beilage, Vol. XIII., No. 2 (December, 1891).

Königl.-böhm. Gesellschaft, Prag: Sitzungsberichte (1891). Jahresbericht (1891). Abhandlungen, Vol. VII., No. 4 (1892).

Siebenbürg. Verein in Hermannstadt : Verhandlungen, Vol. XLI. (1891).

Revue Internationale de Bibliographie Médicale : Vol. III., Nos. 5—10 (March—May, 1892).

Sociedad Cientifica "Antonio Alzate" : Memorias, Vol. V., No. 1—6 (July—December, 1891).

Société des Naturalistes de Kiew : Mémoires, Vol. X., No. 4, Vol. XI., No. 2 (1891).

Société Impériale des Naturalistes de Moscou : Bulletin, 1891, Nos. 2, 3.

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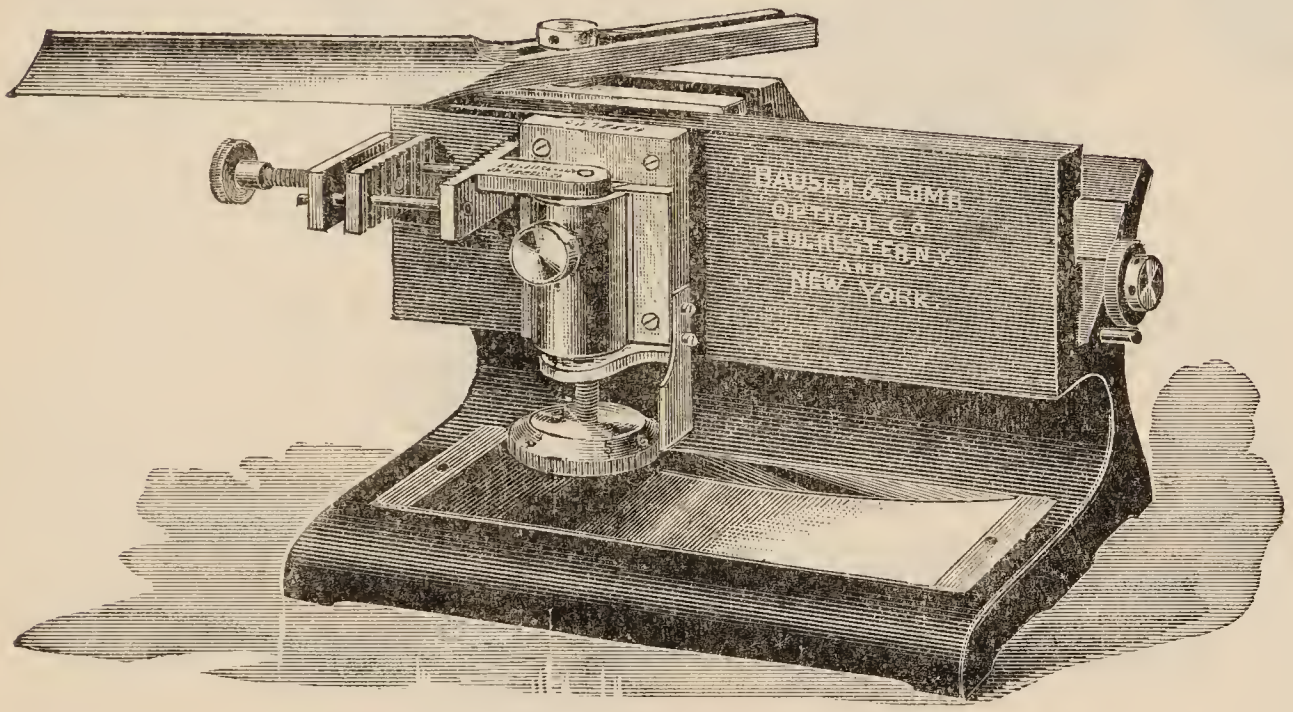

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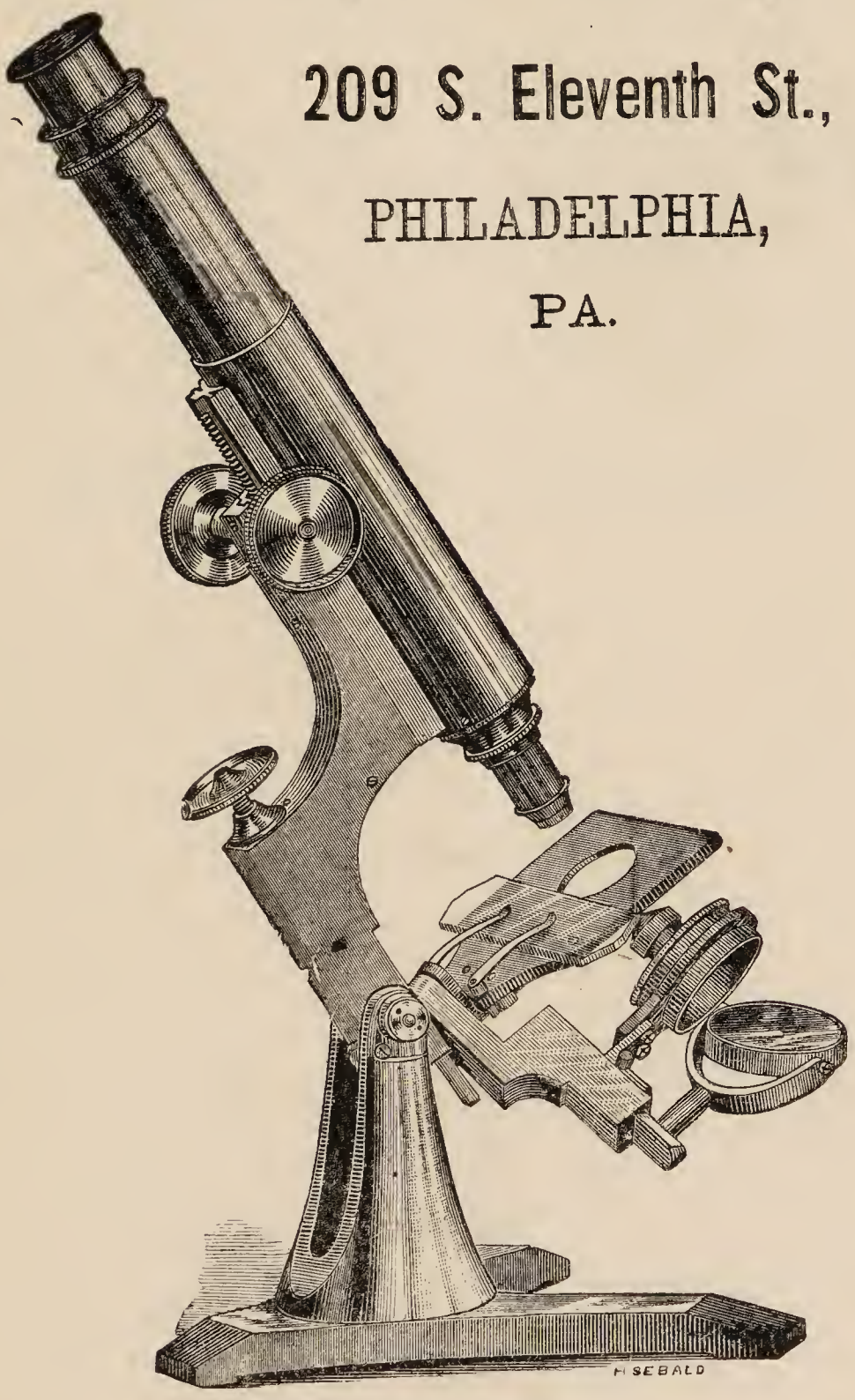

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